UEC Research and Innovation

Latest updates on research and innovation at UEC Tokyo.

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News

6th ASEAN-UEC Workshop on Informatics and Engineering 2024

September 13, 2024

The UEC ASEAN Research and Education Center held the 6th ASEAN-UEC Workshop on Informatics and Engineering on September 8, 2024, at the Academy of Cryptography Techniques (ACT) in collaboration with the ECTI Association (Thailand) and the Radio and Electronics Association of Vietnam (REV). The annual workshop, launched in 2019, offers ASEAN and UEC students the chance to present at international conferences.

This year's hybrid event featured in-person sessions at ACT in Vietnam and Burapha University in Thailand, with additional online participation. The workshop opened with remarks from representatives of the host institutions, followed by seven invited lectures from speakers in Vietnam, Thailand, Indonesia, and Japan.

The second half included 30 student and researcher poster presentations from ASEAN and UEC, with 2 from Vietnam, 19 from Thailand, and 9 from Japan. Seven students presenting at the Thai venue received "Young Researchers Encouragement Awards."

With over 140 participants, this event provided valuable international exposure for ASEAN and UEC students.

Prof. Kitsuwan Nattapong, Director of UEC ASEAN Research and Education Center

Dr. Oya, Member of the Board of Directors (International and Public Relations Strategy)

News

President Tano Visits VGISC (Vietnam)

September 11, 2024

On Friday, September 6, 2024, UEC President Tano, accompanied by Dr. Oya, Board Member for International and Public Relations Strategy, and other UEC representatives, visited the Vietnam Government Information Security Commission (VGISC).

After a welcoming address by VGISC Vice Chairman Nguyen Huu Hung, President Tano expressed gratitude for the ongoing collaboration between UEC and VGISC. The meeting focused on future exchanges between the two institutions.

Since a 2018 cooperation agreement and memorandum of understanding on student exchanges, UEC has welcomed several VGISC staff members as students annually. This visit aims to further strengthen the partnership between the institutions.

Research Highlights：Research

Electronics

Layer-by-layer copper aluminum oxide films for advanced p-type thin film transistors

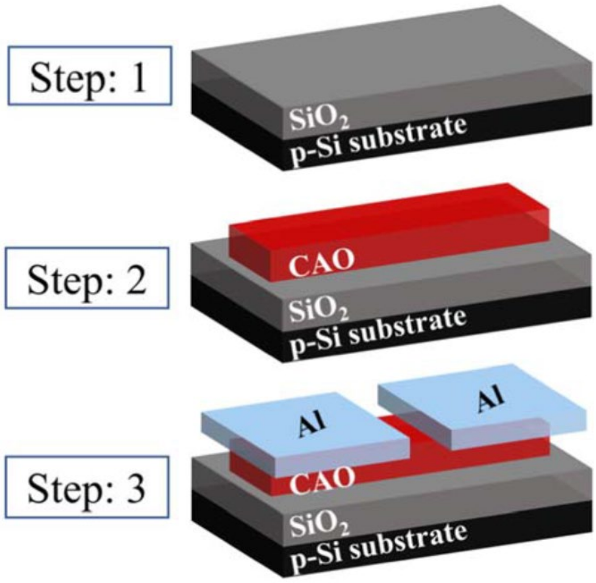
As the basic building blocks of many electronic devices, transistors are an integral part of our society. A particularly widely used type of transistor is the field-effect transistor, in which an electric field is used to control the current in a semiconductor — a material that doesn't conduct current as well as copper and other metals but is also not an insulator like glass. The control of current flow in the semiconductor enables the amplification of electric signals. Field-effect transistors are commonly used to amplify weak signals, for example in wireless communication technologies. Research on transistors is on-going, as fabricating materials for novel transistors, which typically need to be highly crystalline and defect-free, can be challenging. Now, Hideo Isshiki and colleagues from The University of Electro-Communications, Tokyo have succeeded in manufacturing a thin film transistor (TFT) based on copper aluminum oxide (CAO), with initial tests showing promising device characteristics. TFT is a key device for flexible and transparent electronics.

Most field-effect transistors are of the so-called n-type, meaning that the relevant charge carriers are electrons, which are negatively charged. Transistors in which positively charged 'holes' — local electron deficiencies — conduct the current are known as p-type. Generally, electrons are more mobile than holes, which is one of the reasons n-type TFTs are more commonly used. Yet, p-type TFTs are also valuable for complementary MOS(CMOS) system contributing to low power consumption, which is why Isshiki and colleagues aimed to develop a p-type TFT that can be relatively easily manufactured and has good device characteristics.

The researchers used a technique called layer-by-layer sputtering, a method enabling the deposition of atoms onto a substrate in a well-controlled manner. The carefully timed successive release of copper, aluminum and oxygen atoms onto a silicon oxide substrate, followed by thermal treatment, resulted in orderly stacked layers of copper oxide and aluminum oxide. The crystallinity, morphology and chemical composition of the CAO thin film were checked by means of various analytical techniques, including x-ray diffraction and electron microscopy, and found to be excellent. Overall structural integrity of the CAO film is important for achieving higher hole mobility and therefore enhanced electric conductivity.

Isshiki and colleagues then fabricated a TFT by depositing aluminum electrodes on top of the CAO-on-substrate structure. Device characteristics were measured and confirmed to correspond to typical p-type behavior. An important characteristic is the field effect mobility, which was found to be 4.1 cm^2 per volt per second. This value is promising, but the scientists believe it is still possible to improve it by eliminating certain crystallinity issues — a more precisely controlled thermal process may facilitate this.

An important aspect of the research reported by Isshiki and colleagues is that the sputtering process involved digital pulse patterns — the sputter release of atomic material was programmed as the repetition of an optimized cycle — which enables the formation of highly crystalline layered structures. Quoting the scientists: "[Our] layer-by-layer approach offers a promising pathway for controlled stacking deposition routes in the growth of CAO thin films, enabling enhanced performance and device integration."



[Fig. 3a from the paper]
CAO transistor fabrication scheme.

Mehdi Ali, Daiki Yamashita, Hideo Isshiki, Growth of CuAlO2 on SiO2 under a layer-by-layer approach conducted by digitally processed DC sputtering and its transistor characteristics, Jpn. J. Appl. Phys. **63**, 035502 (2024).

URL: https://doi.org/10.35848/1347-4065/ad2aa5
DOI: 10.35848/1347-4065/ad2aa5

Isshiki Lab website

http://www.flex.es.uec.ac.jp/

Research Highlights：Innovation

Food psychology **Moving food sensation**

Eating is essential for humans to stay alive. In addition, the consumption of food has social and cultural connotations. The eating of live fish or other seafood, for example, is a custom that exists in Japan, where it is referred to as “odorigui”, literally meaning “dancing eating”. Live food consumption is an interesting field of study from a psychological point of view — indeed, people may experience different moral emotions when consuming live creatures. Performing controlled psychology experiments with people eating live food is challenging, however. Synthetic moving food offers an alternative means for studying such eating experiences. Now, Yoshihiro Nakata from The University of Electro-Communications, Tokyo, and colleagues have developed a moving, edible robot based on gelatin and sugar [1]. Introducing the concept of human–edible robot interaction, they demonstrated that the robot enables controlled experiments probing the human psychology of animated food consumption.

The robot consisted of a stick-shaped edible part plugged into a socket containing ‘hardware’ controlling the motion. Specifically, the socket functions solely as a connector, with all other pneumatic devices located outside of it. A pneumatic design was used, because of both its drivability and its harmlessness (air can be ingested); changes in air pressure cause the edible stick to deform. For the edible material, Nakata and colleagues used a mixture of gelatin, apple juice, sugar and calcium carbonate. Various experiments were carried out to arrive at the optimal component ratios, resulting in a stick, reminiscent of gummy candy, with the right tensile strength and hardness.

In a first experiment, the scientists asked people to watch videos of the robots showing two types of motion: lateral, swinging movements, and up-and-down movements. They also varied the speed of these movements. These different modes could be generated and controlled by changing the air supply and exhaust in the robot’s pneumatic chambers. Participants were then asked questions regarding their impressions and emotions upon seeing the moving robot.

The main outcome was that lateral motion was perceived as corresponding to a higher degree of emotion, animateness, and intelligence, with medium speed generating the more positive impression. Furthermore, Nakata and his colleagues have performed an exploratory factor analysis, which revealed two distinct factors as being perception and taste as shown in Table 5 of reference 1. In terms of speed, a difference was found between "Short and Middle" compared to "Long” and in the second experiment described below, the researchers used the "Middle" setting, but to be clear, this does not imply that only the "Middle" speed showed a significant difference in the first experiment.

In a second experiment, participants were asked to actually eat the edible robot. They first needed to hold the edible part in their mouth for 10 seconds, to make sure they experienced the sensation of the robot’s motion. After that, they had to bite the edible part off, chew on it, and swallow it. Again, the participants were asked questions, this time assessing the eating experience, including the issue of feeling guilty or not about what they just ate. A comparison experiment was done with the edible robots in non-moving mode. Moving and non-moving modes affected participants perception of the robot's texture, described by the onomatopoeia "kori-kori" (crisp) and "gabu" (grappling) for moving and "munya-munya" (mumble) for non-moving situations. As a potential interpretation of their findings, Nakata and colleagues suggested that participants may attribute lifelike qualities to the robot, such as animateness, emotion and intelligence, which intensifies the eater's perception. The link in Reference 3 connects to a video demonstrating the "Human—Edible Robot Interaction" described in this research.

Although the reported study has some limitations — the developed robots do not yet mimic living creatures, and they need to remain connected to their base for functionality, for example — it establishes human–edible robot interactions as a research direction, opening up many possibilities for future research. Quoting the scientists: "We believe that providing users with the experience of "eating a robot" […] may highlight subconscious human attitudes […] toward living organisms and robots."

[Fig. 5b from the paper]
Pneumatically driven movable robot, with edible part (top) and non-edible base (bottom).

References

1. Yoshihiro Nakata, Midori Ban, Ren Yamaki, Kazuya Horibe, Hideyuki Takahashi, Hiroshi Ishiguro, Exploring the eating experience of a pneumatically-driven edible robot: Perception, taste, and texture, PLoS ONE 19(2), e0296697.

URL: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0296697

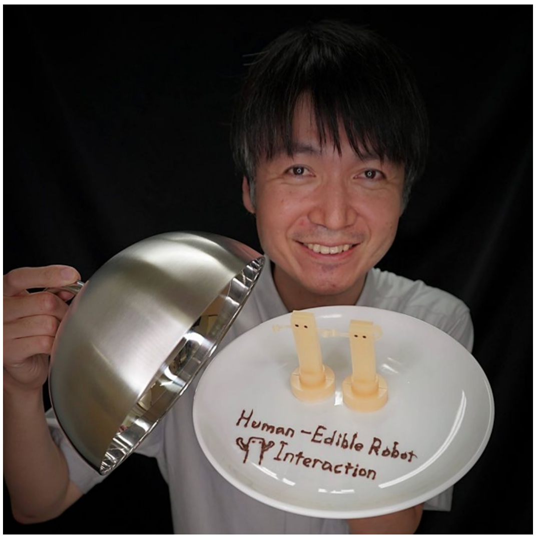
DOI: 10.1371/journal.pone.0296697

2. Table 5 in the paper of reference 2: https://doi.org/10.1371/journal.pone.0296697.t005

3. Demonstration video : Human－Edible Robot Interaction
https://youtu.be/OoAszrv5vy4

Nakata Lab website

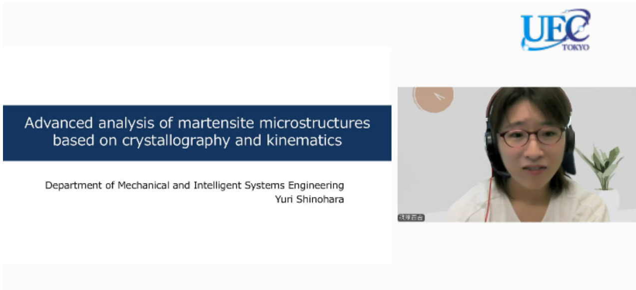
http://www.nakata-lab.mi.uec.ac.jp/home/



Video Profile : Research

Advanced analysis of martensite microstructures based on crystallography and kinematics

Yuri Shinohara
Associate Professor, Department of Mechanical and Intelligent Systems Engineering



Yuri Shinohara, Associate Professor,
Department of Mechanical and Intelligent Systems Engineering.

Yuri Shinohara focuses her research on metallography and crystallography, particularly the study of martensitic transformation in metallic materials. This non-diffusive crystal structure change is significant for its broad industrial applications. A key example of martensitic transformation is observed in iron, where austenite converts to martensite upon cooling and reverts upon heating. This transformation underlies applications in shape memory alloys (SMAs), such as nickel-titanium (Ni-Ti) alloys, which revert to their original shape upon heating after deformation. Additionally, martensite formation is critical in strengthening materials like martensitic stainless steels used for high-strength fasteners.

Shinohara's research seeks to clarify why martensite forms distinct morphologies, such as triangles, zigzags, and hexagons, particularly in iron-based SMAs. These morphologies are not only of scientific interest but are also crucial for practical applications since they directly influence the shape memory effect and mechanical properties of these materials. For example, in Ni-Ti alloys used in medical devices and robotics, the ability of the material to return to its original shape is a result of its martensitic microstructure.

Traditional crystallography has focused primarily on the interface between austenite and martensite but has not provided a full explanation for the observed morphologies. Shinohara's research addresses this limitation by integrating kinematics with crystallography to gain a more comprehensive understanding. This approach is complemented by the use of advanced imaging techniques, including scanning electron microscopy (SEM) and transmission electron microscopy (TEM), to observe and analyze the martensitic microstructures in detail.

The Shinohara and her team have theoretically analyzed and identified misfit at the martensite/martensite interfaces as a key factor influencing morphology formation. For instance, in Fe-Ni-C alloys, specific morphologies such as spear, wedge, and kink are favored so that misfit is minimized. The research showed that these favorable morphologies could be predicted by considering both the austenite/martensite and martensite/martensite interface information. Nearly

2,000 martensite plate pairs were analyzed to validate these findings, demonstrating that spear, wedge, and kink morphologies accounted for over 70% of the observed microstructure.

Moreover, the study explored three-dimensional cluster formations of martensite plates, examining combinations such as double spear, double kink, and diamond configurations. It was found that clusters like the diamond shape accumulated significant misfit (up to 10°), making them less favorable for formation. In contrast, configurations such as double spear and double kink showed no misfit.

The team achieved a significant milestone by successfully visualizing the misfit within the microstructures using a misfit map, which provided detailed insights into how misfit varies at different interfaces. For example, martensite plate pairs with minimal theoretical misfit showed little to no observed misfit, while those with significant theoretical misfit displayed clear misfit that decreased away from the interface.

Shinohara's ongoing research aims to further elucidate the relationship between these martensitic microstructures and their mechanical properties, which could lead to the development of new materials with tailored properties for specific industrial applications. She stresses the importance of interdisciplinary collaboration, inviting researchers from various fields to join in advancing this area of study.

Research Keywords: metallography, crystallography, martensite, shape memory alloys, steel

References and further information

[1] Y. Shinohara, S. Akabane, T. Inamura, Analysis of variant-pairing tendencies in lenticular martensite microstructures based on rank-1 connection, Sci. Rep. 11, 14957 (2021).
https://doi.org/10.1038/s41598-021-93514-z
[2] Y. Shinohara, M. Hishida, Y. Tanaka, T. Inamura, Analysis of thin-plate martensite microstructure in steel focusing on incompatibility and its visualization, Acta Mater. 259, 119275 (2023).
https://doi.org/10.1016/j.actamat.2023.119275
[3] N. Takahashi, S. Shinozaki, Y. Shinohara, Y. Tanaka, H. Kawata, T. Inamura, Geometry of butterfly martensite in Fe-18Ni-0.7Cr-0.5C alloy, ISIJ Int. 64, 202-211 (2024).
https://doi.org/10.2355/isijinternational.ISIJINT-2023-277

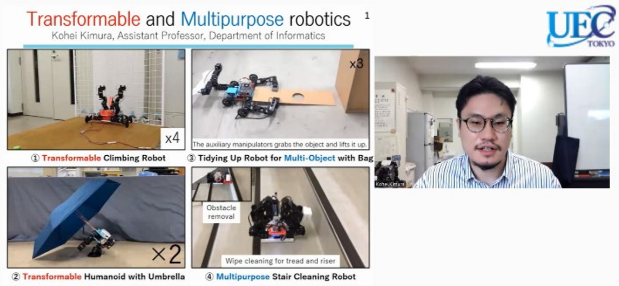
Shinohara Lab Website

https://researchers.uec.ac.jp/search/detail?systemId=29a35663ff7eca4f520e17560c007669&lang=en

Video Profile：Innovation

Transformable and Multipurpose robotics

Kohei Kimura
Assistant Professor, Department of Informatics



In our lab, we focus on developing robotics with two key features: the ability to transform shape to adapt to the environment and the capability to perform multiple tasks.

The research led by Kohei Kimura at the Department of Informatics, Graduate School of Informatics and Engineering, focuses on developing robots with "transformable" and "multipurpose" capabilities. The aim is to create adaptable robots that can change their shape to suit different environments and perform various tasks using a single robotic form.

The project features four main types of robots:

1. **Transformable Climbing Robot**: This robot can switch between wheeled and climbing modes, adapting its form to navigate both horizontal and vertical surfaces. It uses sensors to detect obstacles and transitions seamlessly between different movements.

2. **Transformable Humanoid with Umbrella**: Equipped with a folding umbrella to prevent fall damage, this robot deploys the umbrella upon detecting a fall, cushioning the impact. The robot then stands up and closes the umbrella.

3. **Tidying Robot with Bag**: This robot uses a bag-attached manipulator to collect and organize various objects, including small items that could damage robot vacuum cleaners. The bag accommodates different shapes and quantities safely.

4. **Multipurpose Stair Cleaning Robot**: Capable of cleaning both the horizontal treads and vertical risers of stairs, this robot uses sponges and grippers to wipe surfaces and remove obstacles.

The research underscores the importance of developing versatile robots that can operate across diverse environments, reducing the need for multiple specialized units. By integrating transformable and multipurpose features, these robots are designed to enhance functionality and adaptability in real-world applications.

Future goals include creating robots that combine both transformable and multipurpose traits, potentially working in swarms to expand their capabilities. The research emphasizes the need for robust hardware and software integration to support these multifunctional robots, and it encourages collaboration to drive further innovation.

Research Keywords

Robotics, Climbing Robot, Humanoid Robot, Tidying Robot, Stair Cleaning Robot

References and further information

1. K. Kimura, Transformable climbing robot, Journal of the Robotics Society of Japan, 42(7), pp. 636-641, 2024.

   https://www.jstage.jst.go.jp/article/jrsj/42/7/42_42_636/_article/-char/en

2. K. Ikutama, K. Kawaguchi, M. Takizawa, T. Suehiro, S. Kudoh, and K. Kimura, Confirmation and execution of door closing by a small robot based on open/close decisions using patrolling and body contact, Transactions of the Society of Instrument and Control Engineers, 60(9), pp. 522-535, 2024.

   https://www.jstage.jst.go.jp/article/sicetr/60/9/60_522/_article/-char/en

3. T. Makabe, N. Hiraoka, S. Noda, T. Anzai, K. Kimura, M. Hattori, H. Sato, F. Sugai, Y. Kakiuchi, K. Okada, and M. Inaba, Design and development for humanoid-vehicle transformer platform with plastic resin structure and distributed redundant sensors, In Proceedings of 2022 IEEE International Conference on Robotics and Automation (ICRA2022), pp. 8526-8532, 2022. DOI:

   https://doi.org/10.1109/ICRA46639.2022.9811683

Kimura Lab Website

https://www.robo.lab.uec.ac.jp/~kimura/index_e.html
https://www.robo.lab.uec.ac.jp/en/